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# Pulmonary Embolectomy

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*Embolectomy was carried out in eight patients with pulmonary emboli. Angiographic diagnosis was obtained in six, and in two cases pulmonary angiography could not be done because of the very critical condition of the patients. In the latter two, diagnosis was made based only on clinical findings. Two patients died in the operating room (25 percent). Six patients were discharged in good condition.*

*It is emphasized that pulmonary embolectomy should be done in cases of pulmonary emboli when a clinical status of shock is present (systolic blood pressure less than 80 mm of mercury and the patient in low cardiac output syndrome) and when there is no response to medical treatment regardless of the degree of obstruction in the pulmonary arterial tree.*

PULMONARY EMBOLISM is a life-threatening pathologic condition. It has been estimated that in the United States a total of 193,795 patients are still dying each year due to this complication.<sup>1</sup> The use of embolectomy in the treatment of pulmonary emboli was first suggested by Trendelenburg in 1908,<sup>2</sup> successfully carried out for the first time by Kirschner in 1924 with the use of inflow occlusion technique,<sup>3</sup> and accomplished with the help of extracorporeal circulation by Sharp<sup>4</sup> and Cooley and associates<sup>5</sup> in the early 1960's. The proper role of this procedure still needs to be defined precisely.<sup>6,7</sup>

This report is based upon our experience during the past five years in an active cardiac unit. The role of emergency surgical operation in a certain subset of patients with pulmonary embolism is hereby established.

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## Patients and Methods

In eight patients with a diagnosis of pulmonary embolism, operations were done between 1972 and 1977 at the University of Oregon Health Sciences Center affiliated with St. Vincent Hospital and Medical Center in Portland, Oregon. Details of these cases are tabulated in Table 1.

The patients had low cardiac output syndrome with blood pressure less than 80 mm of mercury. Dopamine hydrochloride and isoproterenol hydrochloride infusions were used to maintain a satisfactory blood pressure. Heparin infusion (1,000 units per hour) and dexamethasone administration (4 mg every four hours) were also started during the preoperative period. Patients had poor response to medical treatment.

Preoperative pulmonary angiography could not be done in two patients because of their clinical condition (in one cardiac arrest occurred and the patient was resuscitated on the way to the operating table and in the other severe shock

## PULMONARY EMBOLECTOMY

and low cardiac output syndrome developed), where presumptive diagnosis was made based on clinical findings. Pulmonary angiography was done in six cases (see Figures 1 and 2), showing diffuse bilateral multiple ischemic areas in four patients (cases 4, 5, 6 and 8), ischemic left lung in one patient (case 2) and ischemic right lung, especially in the middle and lower lobes, in one patient (case 7).

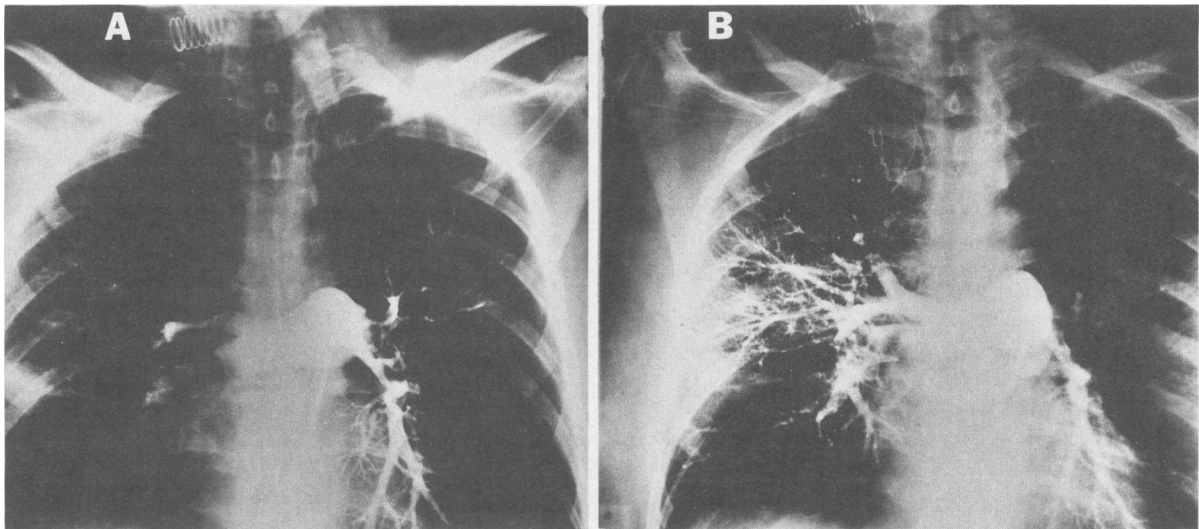
In four patients pulmonary embolism occurred during the early postoperative period after coronary artery surgical operation. In three of the four no anticoagulants were given after open heart operation (case 1, 2 and 4) and in one (case 3) oral administration of an anticoagulant [warfarin

sodium (Coumadin®)] was begun on the second postoperative day. In all the patients in whom coronary artery operations were done, digitalis was given during the postoperative period.

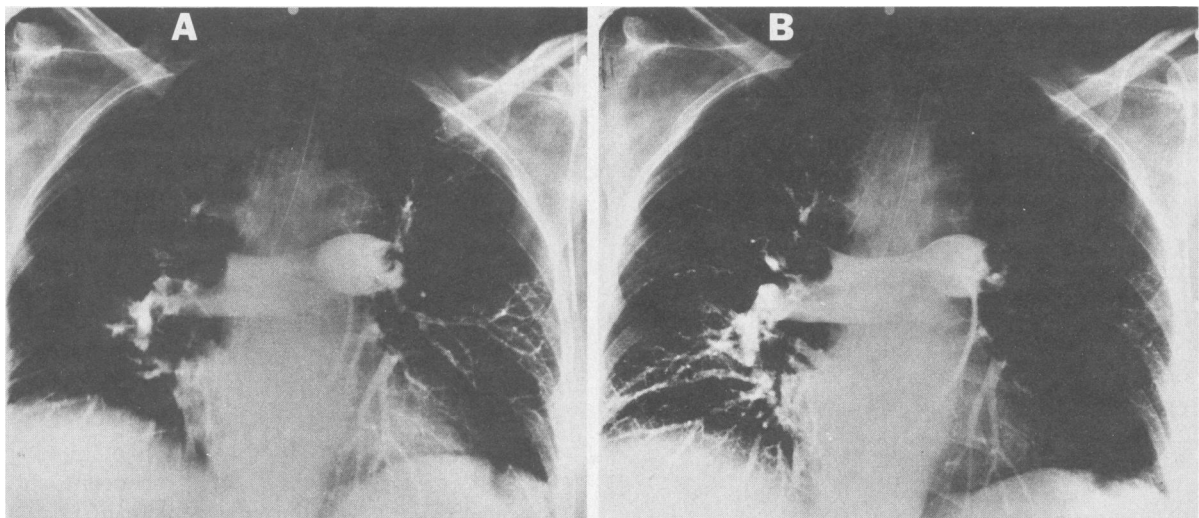
In two patients pulmonary embolism developed after abdominal operations. Two other patients did not indicate any history of recent operation, but they were in bed with lack of activity due to underlying conditions (acute cholecystitis in one, and senile dementia in the other). Signs of phlebitis were observed only in one patient (case 3).

### Operative Technique

Operations were done using cardiopulmonary bypass. The chest was opened with a median



**Figure 1.**—(case 6) **A**, Left pulmonary arteriography; **B**, Right pulmonary arteriography.



**Figure 2.**—(case 8) **A**, Left pulmonary arteriography; **B**, Right pulmonary arteriography.

# PULMONARY EMBOLECTOMY

sternal incision and tapes were placed around the cavae. The heart was fibrillated with the help of epicardial wires after institution of bypass, and longitudinal pulmonary arteriotomy was done after tightening of the tapes around the cavae. Clots were removed from the pulmonary artery by curved forceps and suction. Both pleural cavities were opened, the lungs massaged and milked from periphery to hilus and small clots coming from the periphery were sucked out from the pulmonary artery. The pulmonary arteriotomy was closed, the heart defibrillated, and the patient was weaned off bypass gradually.

Thrombosis of coronary bypass grafts was found in one patient in whom pulmonary embolectomy was done, and thrombectomy of the grafts was also carried out with Fogarty catheters at the same time.

## Postoperative Status and Results

Two patients died on the operating table (25 percent mortality) and the other patients did well

after the operation (see Table 1). In one patient tracheostomy was needed in the postoperative period. Pulmonary pressures were monitored in the cardiac recovery room continuously by a Swan-Ganz catheter introduced into the pulmonary artery during the preoperative period. Digitalis was administered to all patients during the postoperative period, heparin drip infusion (1,000 units per hour) was maintained for a week after the operation and then anticoagulation with warfarin sodium was carried out for three months. Dopamine hydrochloride and isoproterenol hydrochloride infusions were done for a mean of six days (changing between 2 and 15 days) to support the heart during the postoperative period. Dexamethasone was used postoperatively only in two cases for one week.

In two patients additional operations were done during their stay in hospital after pulmonary embolectomy (rib resection and drainage of lung abscess in one, and cholecystostomy in the other).

Six patients were discharged in good condition,

TABLE 1.—Postoperative Status and Results in Eight Patients

Patient	Age	Sex	Recent Clinical History	Degree of Obstruction In Pulmonary Angiography	Operative Record	Result
1.	44	M	.. Double coronary bypass. Chest pain and cardiac arrest on 8th postoperative day.	Angiography not performed.	1. Small amount of thrombus from LPA. 2. Thrombectomy of vein grafts.	Death during operation (autopsy was done).
2.	53	M	.. Single coronary graft. Pulmonary emboli on 10th postoperative day and shock.	40 to 50 percent	1. Large clot from LPA. 2. Operation for lung abscess two months after embolectomy.	Good
3.	67	M	.. Double coronary bypass. Severe chest pain on 14th postoperative day and shock.	Angiography not performed.	Long piece of clot from RPA.	Death during operation (autopsy not done).
4.	63	M	.. Single coronary bypass. Pulmonary emboli on 7th postoperative day.	50 percent	Large clot from LPA.	Good
5.	62	M	.. Patient in senile dementia, pulmonary embolism occurred.	>50 percent	Multiple clots from both sides.	Good. Sent to nursing home.
6.	46	F	.. Abdominal lipectomy and operation for vaginal suspension. Syncope on 10th postoperative day.	>50 percent*	Clots from both sides.	Good
7.	69	F	.. Patient with pacemaker, and cholecystitis in hypotension.	50 percent	1. Clot from RPA. 2. Cholecystostomy five days after embolectomy. 3. Tracheostomy.	Good
8.	64	F	.. Laparotomy for small bowel obstruction. Pulmonary emboli on 15th postoperative day.	>50 percent*	Saddle embolus.	Good

LPA=left pulmonary artery

RPA=right pulmonary artery

\*See Figures 1 and 2.

one of them being sent to a nursing home because he was unable to take care of himself because of senile dementia.

### Necropsy Studies

Permission for autopsy could be obtained in only one of the patients who died during operation (case 1). Necropsy findings in this case showed thrombosis of coronary bypass grafts and thrombotic pulmonary embolus in the left lower lobe. Aorta and coronary arteries were reported to be hypoplastic and it was concluded that vein grafts were occluded mechanically due to the very small diameter of the coronary arteries (less than 2 mm) and poor distal runoff. In this patient there was no other medical cause (such as hypercoagulability) to explain the thrombosis of vein grafts.

### Discussion

Pulmonary embolism occurs commonly in patients with a history of previous operation or chronic illness, in postpartum state or, rarely, in women taking oral contraceptives.<sup>8</sup> Evidence of thrombosis in the lower extremities and pelvic veins is not always a concomitant finding and has been observed in only one of our cases. Massive pulmonary embolism occluding 50 percent or more of the pulmonary arterial tree usually leads to clinical features of shock with a sudden severe reduction in cardiac output, acute right heart failure and disturbance of pulmonary ventilation and perfusion.<sup>8</sup> In rare instances it may also cause paradoxical systemic arterial embolism in patients with a patent foramen ovale or atrial septal defect as a result of increase in right atrial pressure and right-to-left shunt.<sup>9,10</sup> In unilateral pulmonary embolism cardiorespiratory difficulties may be augmented by pronounced spasm in the uninvolved pulmonary artery.<sup>11</sup> Development of cor pulmonale among patients surviving massive pulmonary embolism without embolectomy is extremely uncommon due to the rapid resolution of pulmonary thrombi under appropriate medical and prophylactic therapy.<sup>12,13</sup>

Prophylaxis of pulmonary embolism after coronary artery bypass surgical procedures deserves special mention. In all patients in whom coronary artery bypass operations are done, we carry out anticoagulation with warfarin sodium during the early postoperative period starting on the day chest tubes are pulled out (second postoperative day) and maintain administration of

warfarin sodium until the day of discharge (usually the tenth postoperative day). To date we have observed significant pulmonary embolism needing embolectomy in only four of 2,000 patients in whom coronary artery bypass operations have been done. In a group of 100 patients we have not used any anticoagulation during the postoperative period to assess the importance of postoperative anticoagulation; in three of these there was significant pulmonary embolism needing embolectomy (cases 1, 2 and 4). In all other cases we used routine postoperative anticoagulation and found only one significant episode of pulmonary embolism (case 3). The rate of pulmonary embolism in these two groups of patients shows the importance of short-term postoperative anticoagulation in the prophylaxis of postoperative pulmonary embolism after coronary artery bypass operations.

The clinical diagnosis of pulmonary embolism cannot always easily be made because of such factors as frequency of sudden death, serious underlying diseases and erroneous diagnoses (for example, acute coronary occlusion); these are the most important causes limiting the number of patients who can be salvaged by embolectomy.

Although the diagnosis can be confirmed only by angiography, it may not be possible to carry out pulmonary angiography in some emergency cases, where the diagnosis must be based on history, physical signs, electrocardiographic findings and x-ray films of the chest,<sup>16</sup> as happened in two of our cases. Some surgical groups have advised the institution of an immediate femoral vein to femoral artery bedside bypass under local anesthesia in critically ill patients, and even in cases of cardiac arrest requiring resuscitation, before the transfer of the patients to the radiology department for pulmonary angiography.<sup>6,17</sup>

Acute pulmonary embolism can be treated by medical and surgical methods. Heparin is the most widely used drug for this purpose, and some favorable results have also been reported with the use of thrombolytic agents such as streptokinase.<sup>8,18</sup> Femoro-femoral membrane oxygenator support can be used in selected cases in addition to medical or surgical therapy.<sup>19</sup> Prophylactic methods like ligation or plication of inferior vena cava and insertion of umbrella filters are usually added in cases of continuous predisposition to venous thromboembolism leading to recurrent episodes of pulmonary embolism or when anticoagulation is contraindicated.<sup>15</sup> Fe-

## PULMONARY EMBOLECTOMY

moral vein ligation can be done under local anesthesia as a prophylactic measure in patients who are inappropriate candidates for general anesthesia.<sup>15</sup> We did not carry out any prophylactic surgical procedures such as ligation or plication of the inferior vena cava in addition to pulmonary embolectomy because we believe that adequate postoperative anticoagulation after mechanical removal of blood clots from the pulmonary arterial tree is sufficient for the treatment of patients in whom significant pulmonary embolism occurs for the first time without any previous recurrent embolic episodes.

The definitive surgical treatment for pulmonary embolism is pulmonary embolectomy, and the role of the procedure in the treatment of this pathologic condition still requires a clearer definition. It has been pointed out that patients with massive pulmonary embolism who are normotensive or whose hypotension is responsive to vasopressors do not usually need embolectomy and can be treated by medical and prophylactic measures only.<sup>11,12,15,20</sup> The common point of view in most publications on this topic is that pulmonary embolectomy should be reserved for patients with massive embolism occluding more than 50 percent of the pulmonary arterial tree accompanied by clinical shock.<sup>7,15,21</sup> We also agree with this indication, but we want to add one more point regarding the degree of obstruction in the pulmonary arterial tree. Our experience showed that pulmonary artery obstruction greater than 50 percent should not be a rigid criterion for pulmonary embolectomy because patients with less obstruction in the pulmonary arterial tree (less than 50 percent) are also sometimes candidates for embolectomy if they are in a clinical state of shock not responding to vasopressors.

Mortality after pulmonary embolectomy usually varies between 40 and 60 percent in most of the published reports,<sup>15</sup> although more favorable figures (23 percent) have been reported by

some authors.<sup>7,8</sup> A history of cardiac arrest carries the poorest postoperative prognosis,<sup>8,16</sup> as also noted in our series.

Estimation of late mortality after pulmonary embolectomy is difficult unless necropsy can be done because patients may later die of other underlying diseases.

### REFERENCES

1. Dalen JE, Alpert JS: Natural history of pulmonary embolism. *Prog Cardiovasc Dis* 17:259-270, Jan/Feb 1975
2. Trendelenburg F: Über die operative Behandlung der Embolie der Lungenarterie. *Arch Klin Chir* 86:686-700, 1908
3. Kirscher M: Ein durch die Trendelenburgsche Operation geheilter Fall von Embolie der Art. Pulmonalis. *Arch Klin Chir* 133:312-359, 1924
4. Sharp EH: Pulmonary embolectomy: Successful removal of a massive pulmonary embolus with the support of cardiopulmonary bypass. *Ann Surg* 156:1-4, Jul 1962
5. Cooley DA, Beall AC Jr, Alexander JK: Acute massive pulmonary embolism—Successful surgical treatment using temporary cardiopulmonary bypass. *JAMA* 177:283-286, Aug 1961
6. Beall AC Jr, Collins JJ Jr: What is the role of pulmonary embolectomy? *Am Heart J* 89:411-412, Apr 1975
7. Paneth M, Miller GAH: Massive pulmonary embolism: The role of pulmonary embolectomy. *Am Heart J* 91:133-134, Jan 1976
8. Miller GAH: The diagnosis and management of massive pulmonary embolism. *Br J Surg* 59:837-839, Oct 1972
9. Shaw RC, Ludbrook PA, Weiss AN, et al: Massive pulmonary embolism permitting paradoxical systemic arterial embolism: Successful surgical management. *Ann Thorac Surg* 22:293-295, Sep 1976
10. Poole-Wilson PA, May ARL, Taube D: Paradoxical embolism complicating massive pulmonary embolus. *Thorax* 31:354-355, Jun 1976
11. Marable SA, Winegarner FG, Moore FT, et al: Pulmonary embolism and the indications for embolectomy. *Arch Surg* 93:258-262, Aug 1966
12. Sautter RD, Fletcher FW, Emanuel DA, et al: Complete resolution of massive pulmonary thromboembolism. *JAMA* 189:948-949, Sep 1964
13. Paraskos JA, Adelstein SJ, Smith RE, et al: Late prognosis of acute pulmonary embolism. *N Engl J Med* 289:55-58, Jul 1973
14. Gifford RW Jr, Groves LK: Limitations in the feasibility of pulmonary embolectomy—A clinico-pathologic study of 101 cases of massive pulmonary embolism. *Circulation* 39:523-530, Apr 1969
15. Alpert JS, Smith RE, Ockene IS, et al: Treatment of massive pulmonary embolism: The role of pulmonary embolectomy. *Am Heart J* 89:413-418, Apr 1975
16. Paneth M: Pulmonary embolectomy—An analysis of 12 cases. *J Thorac Cardiovasc Surg* 53:77-81, Jan 1967
17. Beall AC Jr, Cooley DA: Current status of embolectomy for acute massive pulmonary embolism. *Am J Cardiol* 16:828-833, Dec 1965
18. Tibbitt DA, Davies JA, Anderson JA, et al: Comparison by controlled clinical trial of streptokinase and heparin in treatment of life-threatening pulmonary embolism. *Br Med J* 1:343-347, Mar 1974
19. Cooper JD, Teasdale S, Nelems JM, et al: Cardiorespiratory failure secondary to peripheral pulmonary emboli—Survival following a combination of prolonged extracorporeal membrane oxygenator support and pulmonary embolectomy. *J Thorac Cardiovasc Surg* 71:872-877, Jun 1976
20. Alpert JS, Dalen JE: Reply to the editor. *Am Heart J* 91:134, Jan 1976
21. Cooley DA, Beall AC Jr: Embolectomy for acute massive pulmonary embolism. *Surg Gynecol Obstet* 126:805-810, Apr 1968